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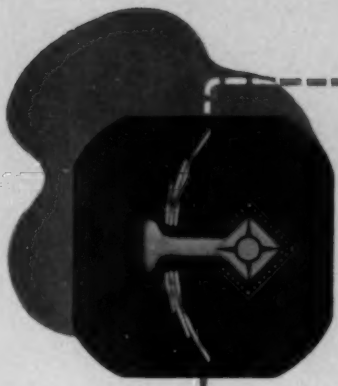

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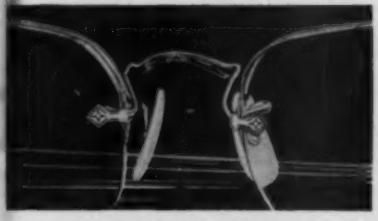

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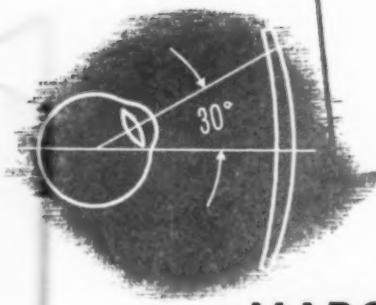

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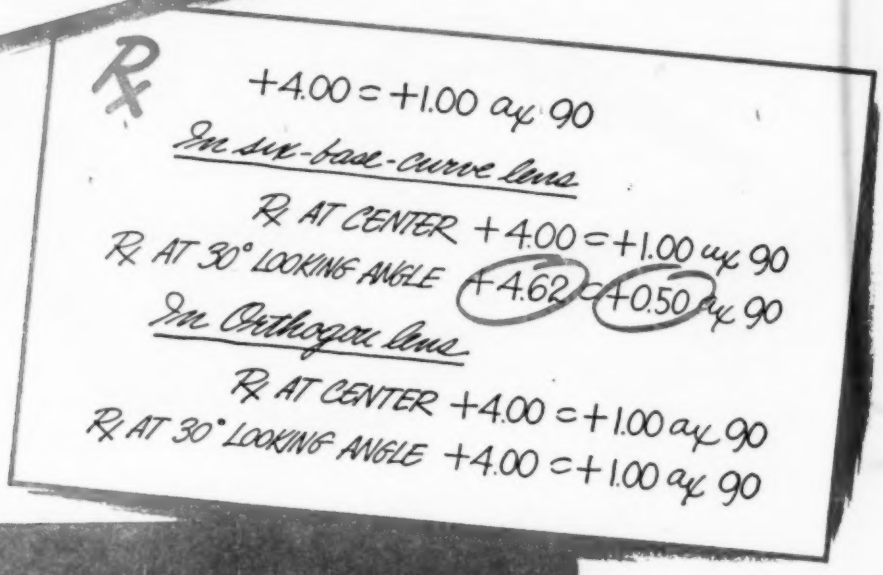
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In six-base-curve lens
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Rx AT 30° LOOKING ANGLE +4.62 = +0.50 ax 90
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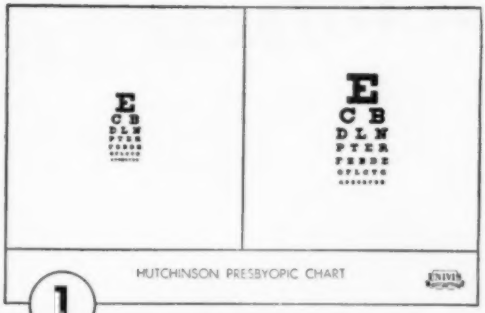

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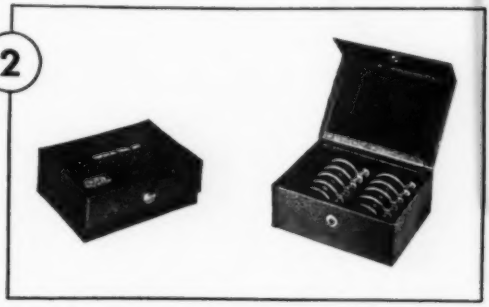

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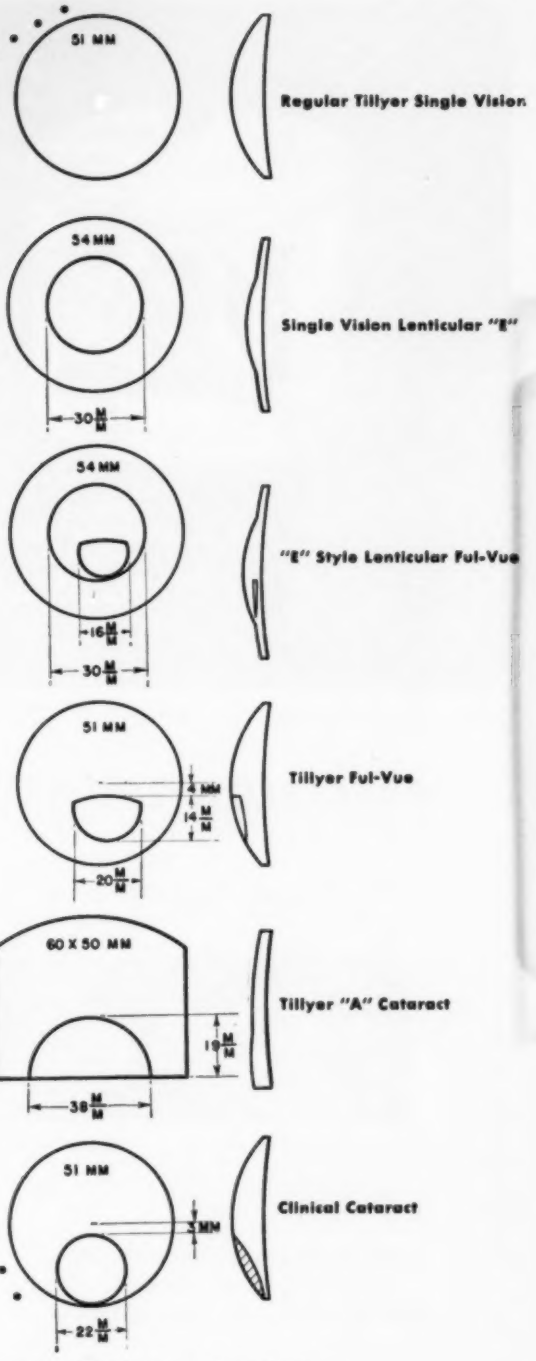

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CONTACT LENSES AND THEIR EFFECT ON NEUROMUSCULAR PATTERNS OF VISION*

Leon E. Firestone† and Ernest M. Gaynes‡
Detroit, Michigan

Contact lens practitioners have been concerned with the problems of physical and chemical fit of contact lenses. There are many authoritative opinions as to which characteristics constitute a "good," or at least adequate, physical fit. Similarly, much work has been done on the chemistry and physiology of contact lens buffer solutions. These are basic aspects of contact lens fitting, but ultimately contact lenses must be analyzed for the optical devices they are. If optometry is to find wider and more successful applications for contact lenses, it must investigate further the effects of contact lenses upon the physiological optics and dioptrics of the eye.

It is a great temptation in working with contact lenses to work only for physical comfort, and regard the optical problems as something time will remedy. The refractive routine commonly used by contact lens practitioners is incomplete at best, being only a cursory, far point subjective examination. Accommodative and convergence relationships are, as a rule, not ascertained or considered.

The purpose of this paper was to determine if contact lenses alter the neuromuscular patterns of vision, as compared to conventional spectacles. To make the investigation as practical as possible no special equipment was used. The standard refracting equipment found in any optometric office was employed: and used wherever possible, with standard, conventional techniques.

Fifty subjects were employed in this study. All subjects selected were patients and each had fairly normal binocular patterns of seeing. No unusual monocular or binocular problems were selected in this series.

*Read before the annual meeting of the American Academy of Optometry at Chicago, Illinois, December 15, 1947. For publication in the March, 1949 issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
†Optometrist. Fellow, American Academy of Optometry.
‡Optometrist.

These individuals represent a relatively normal sampling of refractive cases who wear contact lenses for quite conventional reasons. The investigation was confined to individuals who had been wearing their lenses at least one month, so that any adaptive processes could be assumed to have approached a maximum amount.

The contact lenses worn by the patients who were subjects of this study represent the manufacture of five different laboratories. Although the number of lenses of different manufacture used was not equally divided among the patients, it was felt that by diversifying the types of lenses used, a better indication of what happens to the average contact lens wearer could be obtained. Each lens was fitted to the concepts advocated by the laboratory manufacturing the specific lens involved.

The writers have reviewed 50 case records to secure a comparison between accommodative convergence and phoria tests taken with the patient wearing spectacles, and the same tests made with the patient wearing his contact lenses. No dynamic retinoscopic findings were recorded. Skiascopic reflexes observed on contact lens wearers are difficult to interpret, due probably to peripheral aberrations. This phenomenon has been commented upon by others, and it was decided to eliminate this test from the data studied. It is of interest that in 65 per cent of the patients examined, small amounts of astigmatism were found. These ranged from 0.12 D to 0.75 D. This will be discussed more fully in a subsequent paper.

In evaluating the data of these comparison tests, some allowance had to be made for difference in the subject reaction, and the operators' techniques. Allowable variations were established arbitrarily for each test given. Changes greater than these allowable variations can, then, be considered as significant. It is with these changes greater than the allowable variation that we are concerned.

The allowable variations established for this investigation are tabulated below:

Test	Arbitrarily Chosen Allowable Variations
Induced phoria taken at far.	2Δ
True adduction.	3Δ
Convergence.	4Δ for break or recovery
Abduction.	3Δ for break or recovery
Vertical phoria at far.	1Δ
Induced phoria at near.	2Δ
Dissociated (monocular) cross cylinder test.	+0.50D.
Induced phoria with diss. cross cylinder finding.	2Δ
Binocular cross cylinder finding.	+0.50D.
Induced phoria through binocular cross cylinder findings.	2Δ
Total adductive stimulation.	4Δ
Positive fusional reserve.	4Δ for break or recovery
Total adductive inhibition.	4Δ

Negative fusional reserve. 4Δ for break or recovery
Vertical phoria at near. 1Δ
Amplitude of accommodation. 0.75D.
Tolerance of accommodative stimulation. +0.75D.
Tolerance of accommodative inhibition. +0.75D.
Fusion. No tolerance, graded as good, poor, none.
Stereopsis. No tolerance, graded as good, poor, none.

The tabulation of the data, using the arbitrary allowable variations listed, reveals these differences between tests taken with the patient's spectacles, and with his contact lenses:

SIGNIFICANT DIFFERENCE IN FINDINGS BETWEEN SPECTACLES AND CONTACT LENSES

Test	Per Cent
Induced phoria at far.	38 per cent.
True adduction.	14 per cent.
Convergence.	46 per cent.
Abduction.	28 per cent.
Vertical phoria.	48 per cent.
Induced phoria at near.	56 per cent.
Cross cylinder (dissociated).	8 per cent.
Induced phoria with diss. cross cylinder.	8 per cent.
Binocular cross cylinder.	10 per cent.
Induced phoria with binocular cross cylinder.	8 per cent.
Tolerance of adduction stimulation.	30 per cent.
Positive fusional reserve.	46 per cent.
Tolerance of abductive stimulation.	16 per cent.
Negative fusional reserve.	42 per cent.
Vertical phoria at near.	42 per cent.
Amplitude of accommodation.	20 per cent.
Tolerance of accommodative stimulation.	20 per cent.
Tolerance accommodative inhibition.	2 per cent.
Fusion.	44 per cent.
Stereopsis.	4 per cent.

If it is safe to assume that 50 detailed case records are sufficient to permit some statistical analysis, then this study reveals basic flaws in the present method of fitting contact lenses. Grouping together the tests which show the greatest percentage of significant differences, they are found to be the following: Induced phoria at far, 38 per cent; Convergence, 46 per cent; Vertical phoria at far, 48 per cent; Induced phoria at near, 45 per cent; Tolerance of adductive stimulation, 30 per cent; Positive fusional reserve, 46 per cent; Negative fusional reserve, 42 per cent; Vertical phoria at near, 42 per cent; Fusion, 44 per cent.

These tests only indirectly measure accommodative functions and effects. Primarily they reflect postural changes in the convergence mechanisms induced by the specific contact lenses worn by the patients in this series. Since the greatest differences in the tests given occurred with those tests which measure convergence functions, it is apparent that contact lenses affect convergence functions most, and purely accommoda-

tive least.* This was most significant since the contact lenses used included lenses whose inner radii of curvature varied from 7.5 mm. to 9 mm.

It is also significant that fusion, as measured by the fusion recovery test, is affected. Induced prismatic effects interfered with fusion in 44 per cent of the patients tested. This serves to explain the frequently encountered complaints of discomfort without evidence of physical maladjustment. Many contact lens wearers who express dissatisfaction are undoubtedly being adversely affected by induced prismatic phenomena.

A thorough investigation of the neuro-muscular functions both with spectacles and contact lenses should be included as routine, so that the individual's visual patterns are not disturbed by the contact lenses being fitted. By so fitting contact lenses, or adjusting them, to eliminate induced prismatic effects, many patients can be made comfortable. We feel certain that a large number of those patients who have rather hazy complaints and claim their contact lenses just aren't comfortable, fall into that group in which there is direct interference with their oculomuscular behavior.

There are several factors which may cause a contact lens to induce prismatic effects: (1) The inner and outer surfaces of the contact lens may be inclined towards each other. This creates a true prism, and it can be measured by conventional optical techniques. (2) The inner surface of the contact lens may not be parallel to the outer corneal surface. This would create a water lens which has a strong prismatic element, as shown in the accompanying diagram. Figure 1. (3) The optical center of the contact lens does not coincide with the visual axis. The diagram shows how in this condition a strong prismatic water lens is likewise created, in addition to the prism due directly to the contact lens. Figure 2. (4) The contact lens may shift unduly as it lags during versions and rotations. If after the completed lenses are placed in the patient's eyes, the optometrist should observe induced prism sufficient to disturb the neuro-muscular patterns, he is faced with a difficult problem. To correct the condition he must shift either one, or both of the lenses in such a direction that the prism is eliminated, or neutralized. At

*One of the disturbing factors was trying to find a logical explanation for the fact that significant differences for near and distant blur findings were considerably less than those for near and distant break and recovery findings.
There are two possible explanations that suggest themselves: (1) Most of the patients were myopes, consequently, the retinal image size as compared to their spectacles was increased with contact lenses and the patients may have been less aware of the blurriness. (2) Our arbitrary allowable variations were not consistent in that a higher percentage of change was needed for the blur tests than for the break and recovery tests as compared to normal findings.

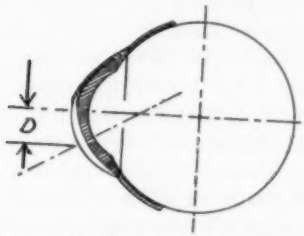

Fig. 1. Eye with contact lens. Inner surface of lens not parallel to outer surface of cornea. Water lens shown between contact lens and cornea. Horizontal line is the visual axis of the eye. D being the distance between the center of the cornea and the center of the contact lens.

the same time the physical fit must not be disturbed, or made unacceptable. Occasionally this can be done, but with great difficulty. Usually it requires the remaking and refitting of new lenses. A better solution of this problem resolves itself into obtaining good centering and parallelism as the lens is being fitted initially. What prism effect occurs can then be eliminated before final optical changes are made.

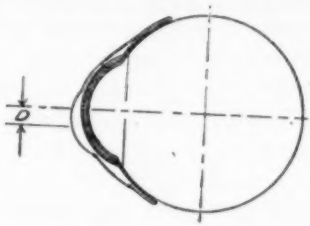

Fig. 2. Eye with contact lens. The optical center of the contact lens does not coincide with the visual axis. Water lens shown between contact lens and cornea. Horizontal line is the visual axis of the eye. D being the distance between the center of the cornea and the center of the contact lens.

To achieve good centering and parallelism the following measures are recommended. These aspects of contact lenses have been discussed in prior papers, or will be in papers to be published. (1) All contact lenses should first be made and fitted as non-optical shells or blanks. All necessary modifications should be made on these non-optical blanks before any optics are incorporated. (2) After all modifications have been performed and the lens fits comfortably, the optometrist should mark the area which corresponds to the visual axis (the center of the pupils will serve, although it does not exactly correspond to the center of the visual axis) and order the optic to be incorporated about this center point. (3) Before a final prescription is ordered from the laboratory,

centering of the lens with primary optics should again be checked. If discrepancies are still observed these should be corrected either by scleral adjustments, or by the laboratory. No final power should be added to a contact lens until there is a minimum of induced prism present. (4) The apex distance of contact lenses should be held to a minimum. This is a basic consideration affecting both optics and fit. Lenses definitely maintain their centering better when the water lens is a thin, rather than heavy meniscus. Prism due to an inclined inner radius with reference to the outer surface of the cornea is of smaller value when the apex distance is least.*

SUMMARY

(1) It has been shown that induced prismatic effects are extremely common among contact lens wearers.

(2) These induced effects are often the cause of so-called contact lens failures.

(3) Suggestions as to minimizing the possibility of induced prismatic effects have been outlined.

*The suggestion for eliminating the difficulties of induced prism in fitting contact lenses are similar to those presented by Eugene Freeman in 1946.

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ABSTRACTS

DISTORTION OF STEREOSCOPIC SPATIAL LOCALIZATION. Kenneth N. Ogle, Mayo Clinic & Mayo Foundation and Paul Boeder, American Optical Company. Journal of the Optical Society of America. 38.8.723. 1948.

As long ago as 1876, O. F. Wadsworth described the spatial distortion produced by unequal magnification in the two eyes. Recently, Adelbert Ames, Jr., has systematically investigated the distortions of space caused by artificially induced aniseikonia, especially of the horizontal, vertical, and oblique meridional types.

In this paper, the authors demonstrate mathematically how most of these distortions can be predicted on the basis of geometry. Stereoscopic spatial localization depends quite rigorously on the retinal disparity of the images seen by the two eyes viewing space from two different vantage points. It is shown that either cylindrical lenses or afocal, meridional "size" lenses, producing unequal retinal image sizes, lead to spatial distortions that generally might be expected on the basis of the retinal disparity. Equations are derived showing the inter-relations of normal and distorted spaces and their dependence upon the nature of magnification introduced and the interpupillary distance.

The mathematical theory adduced fails, at least as far as it goes, to explain the "induced size" effect, whereby a vertical meridional magnification in one eye induces the same spatial distortion as would be observed with a horizontal meridional magnification in the other eye. Because of this effect, an "overall" size lens produces no noticeable stereoscopic distortion of space.

R. E. B.

NOTES ON THE PRECISE PLACEMENT OF BIFOCAL SEGMENTS*

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A report "On the Prismatic Properties of Ophthalmic Lenses" by Safonov and Graham[1] presents equations which connect the coordinates of an object of regard with those of a lens point. The lens point directs light from the object toward the eye's rotational center. The report further comments on the general impossibility of locating bifocal segments utilizing only the prismatic properties of the prescription to determine the placement of the reading segment. However, it is possible to use these equations to precisely locate a bifocal segment on the distance lens if one permits extraneous prism to be introduced.

The following makes use of equations (1) through (6) and the conventions defined in the report. Let the reading matter be held in a point, (H, V, ϵ), of the median plane and let the vertical lens coordinate of the segment be y. In equations (1) and (2) the quantities y, e, ϵ, H, F_s, F_c and α are to be considered as specified.

These equations may then be solved for the two remaining quantities, V and x, in terms of those specified. Solution of (2) for V yields

$$V = \frac{y\,\frac{2\epsilon}{e}\,[\,1-e\,(1-\frac{e}{\epsilon})\,F_s\,] - H\,(1-\lambda)\,\sin 2\alpha}{1+\lambda-(1-\lambda)\cos 2\alpha}$$

where

$$\lambda = \frac{1-e\,(1-\frac{e}{\epsilon})\,F_s}{1-e\,(1-\frac{e}{\epsilon})\,(F_s+F_c)}$$

Now the appropriate vertical coordinate for the reading matter is

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*Read before the annual meeting of the American Academy of Optometry at Winston-Salem, North Carolina, December 7, 1948. For publication in the March, 1949, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

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[1] A report to the Optical Society of America, October 28, 1948. February, 1949 issue, Journal of the Optical Society of America.

$\frac{\epsilon}{e}$ y, thus an amount of vertical prism (base up) is needed to reduce the above V to this desired level. This amount is

$$\frac{V - \frac{\epsilon}{e} y}{\epsilon - e}$$

The horizontal inset, x, is determined by using V in equation (1).

The equations of the report provide a means to rigorously compute both the magnitude of "slab-off" prism and the horizontal inset required for the efficient placement of a segment before each eye.

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ABSTRACTS

ALTERNATING STIMULATION TO OVERCOME NEUTRALISATION. S. Banes. The Optician. (London). 116. September 24th issue. 1948.

One of the most difficult conditions to overcome is neutralisation, i.e., suppression. This is particularly true in squint cases complicated by abnormal retinal correspondence. It is believed that neutralisation (suppression) exists only when the two eyes are receiving stimulation simultaneously. Apparently, this explains why occlusion helps so often in breaking down suppression.

The author describes his technique of stimulating the macula of each eye alternately by a simple device which he has constructed for use with the synoptophore. At first, the targets are exposed with a slow alternation while the synoptophore is set at the true angle of squint. Gradually the speed of alternation is increased until the eyes are receiving stimulation simultaneously. If suppression occurs as the rate of alternation is increased, the speed of alternation is reduced until both eyes are functioning. This process is repeated until the area of suppression is reduced or eliminated.

The author has used his technique at the orthoptic clinic of the London Refraction Hospital and he has compared results with other methods. In general, his conclusion is that the technique of alternate stimulation will break down monocular supression quicker than the usual method of monocular occlusion.

R. E. B.

OBSTACLES TO BINOCULAR VISION. C. L. Treleaven and R. E. Bannon. Journal of the New York State Optometric Association. 15. June, July, August and September, 1948.

Following a brief introduction of the early concepts of strabismus, the etiological factors (mechanical, fusional, and innervational) of strabismus are reviewed. Case histories are given to illustrate these three factors individually and in combinations.

The sensory obstacles to binocular vision include amblyopia, anisophoria, and aniseikonia. Further case histories, including one of "horror fusionis," are given to indicate the role of these sensorial factors, especially aniseikonia, in producing disturbances in binocular vision. References are given of other writers who have had experience in the correction of aniseikonia and have found it to be of significance in binocular problems of strabismus, heterophoria, anisometropia, and amblyopia.

Aniseikonia is about in the same process of evolution as occurred about 50 years ago in the measurement and correction of astigmatism. The task remains for the ophthalmic professions to determine more fully the extent to which aniseikonia will be given more routine consideration in cases of binocular dysfunction.

R. E. B.

PATIENT WITH EXOPHTHALMIC GOITER FITTED WITH CONTACT LENSES*

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CASE HISTORY.

Patient: Male, age 26.

Ocular history: This case was referred to the writer for investigation into the possibilities of raising the vision with the aid of contact lenses. Present vision not satisfactory for the patient's vocation, that of a draughtsman. Some five years ago this patient had undergone a classical thyroidectomy. There has been a slight post-operative improvement in the vision, according to the patient.

PRELIMINARY EXAMINATION.

Lids. Considerable retraction of the upper lids, typical manifestations of Graves disease, true Dalrymple symptom.

Superficial cornea. Clear, but patient suffers severely from epiphora.

Superficial sclera. High degree of proptosis, measuring (using Gifford's method) from the external angular process to the frontal plane, the amount of protusion appears to be 5 mm. in excess of the general accepted normal.

Versions. Restriction on convergence, Moebious symptom.

Pupillary reaction to light. Direct. Normal. Consensual. Normal.

Pupillary reaction to accommodation. Abnormal.

OPHTHALMOSCOPIC EXAMINATION.

Cornea. No apparent malformation.

Aqueous. Fairly normal, showing distinct tendency to depth.

Lens. Normal.

Vitreous. Some opacities, this could be justified as the clinical picture of the myopia present. Extra fluid.

Fundus. General condition healthy, disc, marginal blurring, no definite indication of pathological process.

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*Submitted as portion of the entrance requirements of the American Academy of Optometry. Approved by the committee on admittance. For publication in the March, 1949 issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist. Fellow, American Academy of Optometry. Fellow, British Optical Association.

ANALYTICAL EXAMINATION.

Visual acuity (without correction): Binocular vision 6/90. R. E. V. 6/90. L. E. V. 6/90.

Visual acuity (with new spectacle correction): Binocular vision 6/12. R. E. V. 6/12. L. E. V. 6/12.

Retinoscopy:

R. E.—6.00 D. S. ⌒ —0.50 D. C. Axis 90°
L. E.—6.00 D. S. ⌒ —0.50 D. C. Axis 90°

Subjective test at 6 meters:

6/90. R. E.—6.50. D. S. ⌒ —0.50. D. C. Axis 90° 6/12.
6/90. L. E.—6.50. D. S. ⌒ —0.50. D. C. Axis 90° 6/12.

Vertical phoria. Orthophoria.

Horizontal phoria. Convergence insufficiency.

Contact lens fitting:

		Right Eye	Left Eye
℞. Scleral radius	=	12.50 mm.	12.50 mm.
Corneal radius	=	8.00 mm.	8.00 mm.
Corneal diameter	=	13.00 mm.	13.00 mm.
Overall diameter	=	21.00 mm.	21.00 mm.
Added power	=	— 6.50 D.	— 6.00 D.
Vertex distance	=	11.00 mm.	11.00 mm.
V. A. with C. L.	=	6/6	6/6
Binocular V.	=	6/6	

Solution used. Sodium Bicarbonate

This patient has developed a very high degree of tolerance and wears his contact lenses constantly. The improvement in his vision is very great; so much so, that he has completely abandoned his spectacles.

He has lately been involved in a motor smash and received a fracture at the base of the skull; fortunately there has been no serious ophthalmic complication. He finds his contact lenses very much more adaptable to his work than spectacles have ever been.

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A STUDY OF SOME ASPECTS OF PERIPHERAL VISUAL ACUITY*

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PARTS II, III and IV.‡

PART II. THE METHOD

Apparatus. The reader is referred to Figure 3. A tangent screen, B_2, was designed for a 20 foot distance from the subject. A screen, B_1, of similar size was placed at right angle to B_2 and also at 20 feet, as measured by the line of vision, from the subject.

A half-silvered mirror, MR, was placed at a 1 foot distance before the subject at such an angle that under proper lighting either screen B_2 or B_1 could be seen to the exclusion of the other.

An electronic timer, ET, was connected to the lights illuminating both boards so that when the portable hand switch, SW, was compressed, B_1 would be illuminated for whatever duration of time ET was set previously. Simultaneously, the lights on B_2 would be extinguished for the same period. Thus, photopic conditions were maintained at all times.

A central fixation point, PR_1, was the sole marking on screen B_1. This coincided exactly with the fixation point, PR_2, on tangent screen B_2 when observed through MR and when the lighting of the two screens was alternated on and off.

Tangent screen, B_2, was prepared with the usual angular deviations from the center and map pins were placed on each of the eight meridional points for each tangent degree.

The targets (see Figure 4) used were Landolt rings photographed to respective sizes, 0.1 to 2.0, from a large drawing and mounted on square boards. These had on obverse side linen or metal loops in each of the four positions corresponding to the up, down, right, and left positions of the break in the Landolt ring (see Figure 5). These loops

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*A thesis submitted to the faculty of Purdue University, in partial fulfillment of the requirements for the degree, Doctor of Philosophy, and published with their approval. Submitted on September 9, 1948, for publication in the March, 1949, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF THE AMERICAN ACADEMY OF OPTOMETRY.

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‡Part I appeared in the February issue.

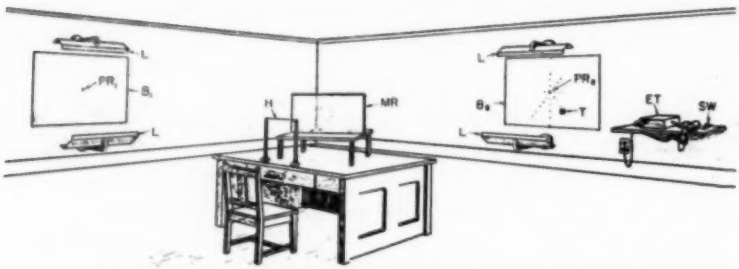

Fig. 3. Apparatus Used for Measuring Peripheral Visual Acuity.

permitted placing the target anywhere on B_2 by placing a loop over one of the map pins.

A headrest, 1 foot from MR, completed the apparatus.

Illumination was presented through the use of lumaline fixtures, L, above and below each board. Fifteen foot candles of light illuminated the visual target.

Fig. 4. Landolt Ring Target (Front).

Technique of administering tests.

Subjects. Four male and four female subjects of age range 22 to 36 participated in this study. Each used the right eye only, the left eye being occluded throughout the experimentation. All were thoroughly instructed in the nature of the experiment and were given trial exposures to the stimuli.

The subject was seated behind the mirror, MR, with his forehead against the headrest, H. Upon a "ready" signal from the observer, the subject was instructed to fixate upon the point of regard, PR, which to the subject appeared to be directly ahead. Immediately following the tachistoscopic presentation of the central or peripheral target, T, the subject was instructed to respond by either "top" or "bottom," or "right" or "left," depending upon his judgment of the break position

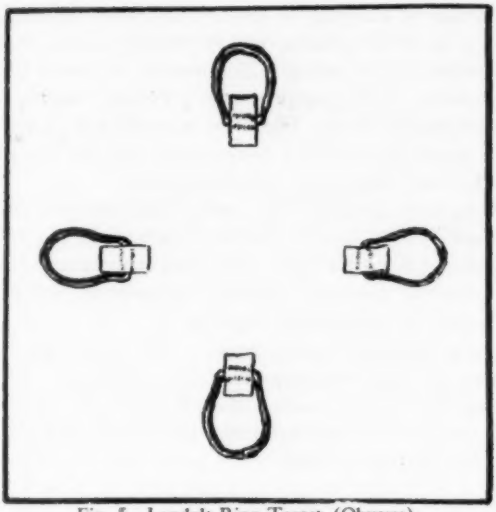

Fig. 5. Landolt Ring Target (Obverse).

in the Landolt ring. S was advised to "guess," if necessary, at each presentation even if the identification of the break position appeared to be simply a chance factor. Because of the possibility of fatigue factors affecting the judgments of S, the period for any given session did not exceed 45 minutes.

Observer. The observer, O, stood before the tangent screen, B_2. Because of the light reflected from fixation screen, B_1, via mirror, MR, to the subject's eye, the observer was invisible to the subject. It, therefore, was a simple matter to change the meridional position of the target, T, as well as to rotate the break position of the Landolt ring without providing any cues to the subject.

O placed each target in its respective position upon the tangent screen, B_2, as indicated on the record form. Immediately after suspending the target on B_2 the observer called "ready!," stepped out of the line of vision of S, waited a moment, and then compressed the electronic flash timer switch, SW, which was carried in his hand. The subject's response then was recorded immediately.

Measuring point of regard visual acuity. The limen of visual acuity for point of regard vision was ascertained for each subject by means of the constant process. The procedure was as follows:

The targets used in this research, as previously discussed, were Landolt rings. Each could be presented in any of four positions, that

is, with the break in the ring at the top, bottom, right or left.

From five to seven targets, size increments equal, were used, and each was presented to the subject 20 times at the point of regard, PR. To assure random order, a previously prepared double fatigue order listing of positions was used. The form was checked in accordance with the subject's correct or incorrect judgments, and the percentage of correct answers for each size target was determined.

All results were corrected for "guess," the resultant corrected scores introduced directly into Urban-Mueller constant process tables, and the limen for point of regard visual acuity was determined (see Table 2). Each set of observed data was plotted to a curve of best fit and a sample of such a curve is depicted in Figure 6.

Measuring peripheral visual acuity. The procedure here was precisely like that of the foregoing with one exception. In determining limens of peripheral visual acuities, the subjects were requested to maintain fixation upon the central fixation point at PR, and the targets were presented in the peripheral field.

TABLE 2
POINT OF REGARD VISUAL ACUITY FOR EIGHT SUBJECTS

Subject	Point of Regard Visual Acuity	
	Decimal	Snellen
MB	.930	20/20.4
ED	.859	20/23.2
HG	.485	20/41.2
JK	1.126	20/17.8
CM	1.157	20/17.2
JM	.885	20/22.7
HS	.613	20/32.6
MZ	1.199	20/16.6

The timer was set for a flash duration of 0.18 seconds. In preliminary trials it was found that this period gave sufficient exposure without allowing the subject time to shift his eyes. However, to provide a consistent technique, the subject was instructed to maintain fixation at PR whenever the "ready" signal was given.

The peripheral targets were presented at all eight meridional positions at 1°, 2°, 3°, 4° and 5°. Each degree of increased angular distance from the point of regard was investigated completely in all positions before going on to the next. Moreover, the meridional positions were listed for each degree in random order and the targets were so presented. Therefore, a target was presented not only in any of four positions in regard to the break in the Landolt ring but also in any of eight meridional positions for each degree. There were eighty pre-

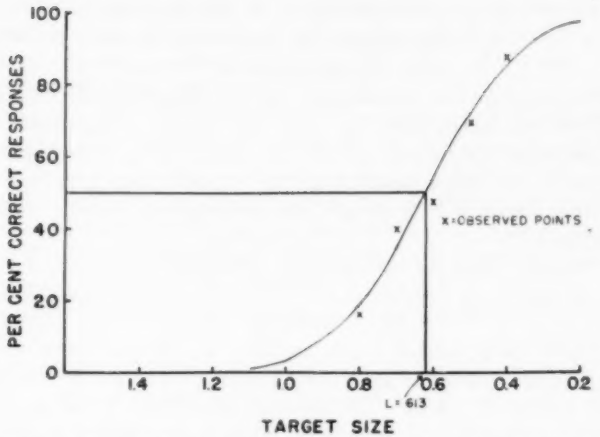

Fig. 6. Point of Regard Visual Acuity Fitted Curve to Observe Data (Subject: HS)

sentations of each target in random order among the meridians and in random order in regard to the break position. Thus, there were 10 presentations of each target for each meridian at each degree.

The subject's responses were recorded as previously.

PART III. STATISTICAL CONSIDERATIONS OF STUDY AND TREATMENT OF DATA

To determine the threshold acuity for any given position of the target stimulus, the constant process or method of constant stimuli was used.

As the condition of equal steps in the series is desirable in this method, targets were presented as indicated in Part II at equal decimal notation gradations. Each of five to seven stimuli was presented 20 times for determining the point of regard visual acuity and 80 times for each degree from the point of fixation. The latter larger number breaks down into 10 presentations at each of the eight meridional points per degree.

The responses were recorded as "right" or "wrong" and corrected for guess by application of the formula:

$$S = R - \frac{W}{N - 1}$$

where S = the test score corrected for chance success
R = the number of right responses

W = the number of wrong responses
N = the number of alternative responses per item (in this investigation N = 4)

The frequency of the subject's correct judgments is a function of the size of the target stimulus (the psychometric function). Thus, when the target size is very small, the percentage of correct judgments in regard to the break position of the Landolt ring approaches zero. When the target is very large, the percentage of correct judgments approaches 100.

The Phi Function of Gamma. This is a mathematical function which satisfies these conditions. It is a form of the probability curve known as the $\Phi(\gamma)$, phi function of gamma. This normal ogive theoretically never reaches 0 per cent or 100 per cent although these values may be obtained in an actual experiment which is concerned with a small number of cases. The assumption is that, if the experiments were repeated an infinite number of times under ideal conditions, the percentages of correct answers plotted against the stimulus values would produce a perfectly smooth normal ogive.

If a chart is prepared with the abcissa representing the target size and the ordinates the observed proportion of correct judgments for each of the stimuli, it can be seen that an empirical ogive will be formed. The procedure of the method of constant stimuli consists in fitting to this empirical curve by the method of least squares a curve of the form:

$$y = \frac{1}{\sqrt{2}} \int_{-\infty}^{S\text{-}T} e^{-\frac{(S\text{-}T)^2}{2\,\delta^2}}\, ds$$

The threshold or limen is then defined as the abcissa of the point at which the ordinate of the theoretical curve of best fit has the value of .500.

The actual procedure for fitting this curve has been presented by Urban,[35] Boring,[2, 3] Culler,[6] Titchener,[34] Brown and Thompson,[4] Guilford,[18] and Woodworth.[37] An excellent example of the application of this procedure may be found in the study of the psychophysics of the vibrato by Tiffin.[33]

Rich's checking tables[20] were used to corroborate the computation accuracy.

The process of linear interpolation was resorted to in a few instances at the outermost field points where there were too few values obtained to use the method of constant stimuli. These are indicated by asterisks in the tables.

To determine the limen for each meridional (or regional) position, a rolling average of the percentages of correct answers at three adjacent meridional positions at a time was calculated. This provides a larger N, establishing more reliable results.

Altogether 288 tables employing the constant stimuli process and 288 accompanying curves were prepared for determination of limens in this study.

Further statistical treatment of the data consisted of a determination of the standard deviation for each limen, the average or mean threshold of all eight meridional positions at each degree for each subject, its standard deviation and variance.

Analysis of variance was made of the data obtained from two subjects.

Analysis of Variance. Variance may be considered, states Guilford,[17] as, simply and roughly, a more exact expression for the concept "individual differences." He emphasizes also that the analysis should be regarded as statistical rather than observational in the ordinary sense.

For careful perusal of the subject the significance and statistical treatment of analysis of variance is presented in the texts of Edwards,[11] Garrett,[16] Guilford,[19] and Peters and VanVoorhis.[31]

Briefly, it can be stated that in this present study the usage of analysis of variance was adopted primarily to determine statistically whether the meridional variations in peripheral visual acuity were due to more than simply chance factors. Secondly, although there is undisputed anatomical and physiological evidence of the increasing decrement of visual acuity at heightening distances from the point of regard, analysis of variance presents statistical evidence of whether this phenomenon may be explained by chance.

PART IV. RESULTS

The point of regard visual acuity for the eight subjects studied ranged from 0.485 to 1.199 decimal acuity (see Table 2).

An example of a fitted curve to observed data in the derivation of the limen point of regard visual acuity may be seen in Figure 6.

Tables 3 and 4 present an example of the summarized data acquired for each subject. Table 3 gives the peripheral visual acuity thresholds at the meridional and regional positions. Table 4 shows the variance of the limens of these points. It is to be noted that the variance decreases as distance from the point of regard increases.

The peripheral visual acuity curves for all eight subjects were computed (see Figure 7). It may be noted that there are wide individual

differences in the retention of levels of visual acuity away from the point of regard. Of the eight subjects, two presented such rapid fall of peripheral acuity as distances beyond the point of regard were increased, that their thresholds were unable to be measured beyond 4°, and one was concluded at 3°.

Regional and meridional variations of peripheral acuity for each subject were studied, and mean scores for all positions at each degree

TABLE 3
PERIPHERAL ACUITY THRESHOLDS
Subject: ED
(P. R. Acuity = .859)

Regional Position	Visual Acuity Thresholds Distance from Point of Regard 1°	2°	3°	4°	5°
1	.589	.387	.375	.323	.210
2	.527	.394	.321	.317	.131
3	.525	.294	.299	.305	.143
4	.575	.303	.286	.304	.176
5	.605	.368	.322	.294	.222
6	.557	.399	.333	.279	.201
7	.528	.412	.343	.280	.177
8	.554	.444	.368	.318	.147
Total	4.460	3.001	2.647	2.420	1.407
Mean	.558	.375	.331	.303	.176

TABLE 4
STANDARD DEVIATIONS OF PERIPHERAL VISUAL ACUITY THRESHOLDS
Subject: ED
(P. R. Std. Dev. = .3421)

Meridional Position	Standard Deviations Distance from Point of Regard 1°	2°	3°	4°	5°
1	.2032	.1514	.1149	.1067	.1767
2	.1666	.3274	.1607	.1229	.2486
3	.1860	.2495	.1295	.1026	.1954
4	.2479	.2862	.1316	.1138	.1449
5	.3318	.2021	.1377	.1239	.1785
6	.2013	.1560	.1289	.1167	.1721
7	.1962	.1644	.1061	.0847	.1666
8	.2417	.1259	.0981	.0852	.1699
$\Sigma\delta^2$	.4126	.3823	.1296	.0934	.2703
δ^2	.0516	.0478	.0162	.0117	.0338
δ	.2272	.2186	0.127	0.108	0.184

removed from the point of regard were computed as well as standard deviations and variances of these scores. An example of the tabular and graphic treatment of such data may be found in Tables 3 and 4 and in Figures 8 and 9. The figures respectively depict one subject's visual acuity compared with the distribution of retinal cones at increasing distances from point of regard, and the variance of his visual acuity thresholds at these distances. The limen scores of residual acuity at

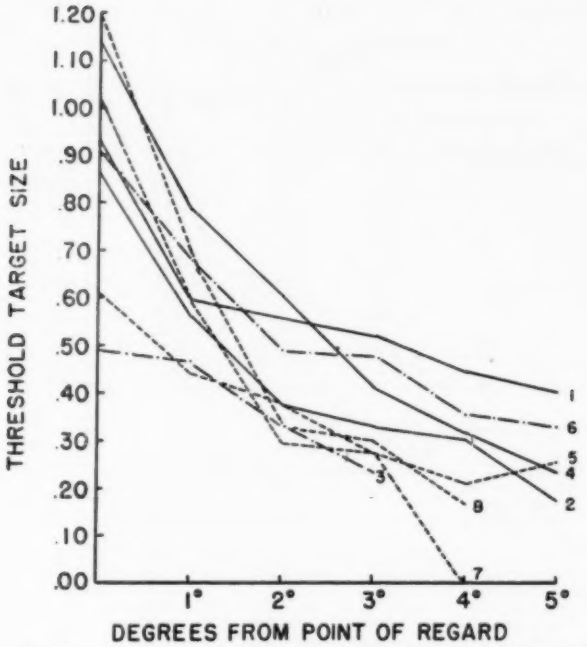

Fig. 7. Variation in Visual Acuity at Increasing Distances from Point of Regard (N=6)

each degree were translated into percentages (point of regard visual acuity equalling unity) in order to make them comparable. It was possible then to summate the data of seven subjects (excluding the one subject from the total who could not advance beyond 3°). (See Table 5.) Similarly, the data of five subjects were summated (see Table 6).

As Ludvigh[27] points out, if visual acuity is dependent upon the discrimination of linear extents, the square root of the number of cones would be a deciding factor, while if visual acuity were primarily dependent upon the discriminations of areal extent, then the number of cones per square mm. would be the determining factor in the visual acuity variation from point of regard outwards.

Employing his graphic comparison method, the mean threshold acuities were plotted against cones /mm.^{2} and $\sqrt{\text{cones}}$ /mm.^{2} This was done for the data obtained from the seven subjects (see Figure 10) and for the five subjects (see Figure 11).

TABLE 5
PERIPHERAL VISUAL ACUITY
(Percents of P. R.)
(N = 7)

Subject	Distance from Point of Regard 1°	2°	3°	4°	5°
MB	.640	.600	.565	.483	.437
ED	.650	.437	.385	.353	.205
JK	.702	.543	.366	.275	.215
CM	.511	.248	.234	.180	.218
JM	.766	.551	.542	.407	.368
HS	.713	.608	.454	.055	
MZ	.566	.279	.244	.142	
X	4.548	3.266	2.790	1.785	
M	.569	.408	.349	.223	
ΣX^2	3.002	1.658	1.216	.649	
δ	.228	.202	.174	.177	
δ^2	.052	.048	.030	.031	
V	40.1	49.5	49.9	79.3	

TABLE 6
PERIPHERAL VISUAL ACUITY
(Percents of P. R.)
(N = 5)

Subject	Distance from Point of Regard 1°	2°	3°	4°	5°
MB	.640	.600	.565	.483	.437
ED	.650	.437	.385	.353	.205
JK	.702	.543	.366	.275	.215
CM	.511	.248	.234	.180	.218
JM	.766	.551	.542	.407	.368
X	3.269	2.379	2.092	1.698	1.443
M	.654	.476	.418	.340	.289
ΣX^2	2.173	1.211	.950	.632	.462
δ	.027	.236	.122	.105	.095
δ^2	.000	.056	.015	.011	.009
V	4.1	49.5	29.2	30.8	32.8

Meridional comparison (1 vs. 5) of peripheral visual acuity (N = 5) is shown in Figure 12.

For the five subjects, the summated data present the following mean percentages of visual acuity (point of regard visual acuity equalling unity) remaining at these peripheral levels:

Point of Regard	100%
1°	65
2°	58
3°	41
4°	35
5°	29

In addition to the above studies, analysis of variance of the results of two subjects were made: 1) Subject: JM. 2) Subject: ED.

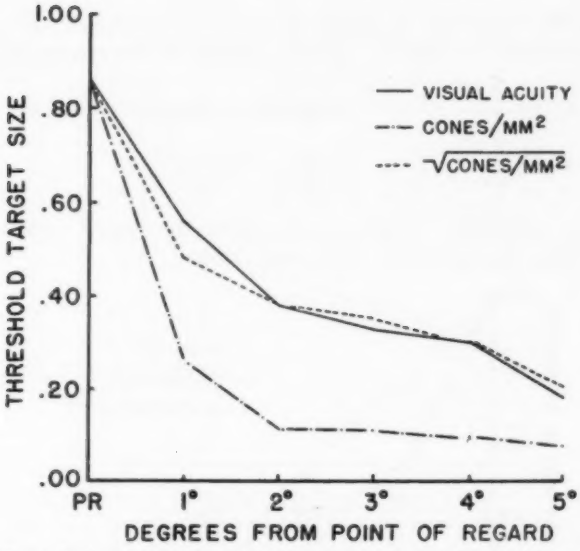

Fig. 8. Visual Acuity Compared with Distribution of Retinal Cones (27) at Increasing Distances from Point of Regard. (Subject: ED)

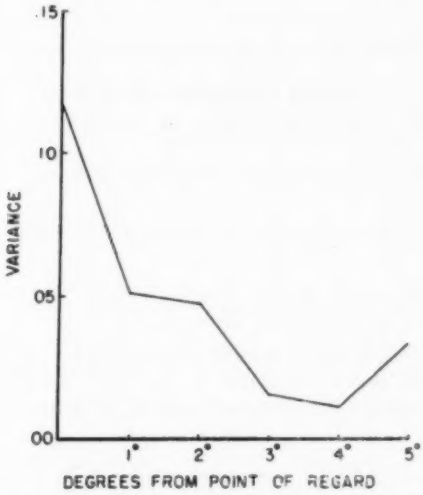

Fig. 9. Variance of Visual Acuity Thresholds at Increasing Distances from Point of Regard. (Subject: ED)

Subject: JM

The column to column (that is, degree to degree) variation as observed, $F_c = \frac{\hat{\sigma}\ c^2}{\hat{\sigma}\ e^2} = 47.7$, compared to Snedecor's F ratio,

$F.05\ n_1 = 4,\ n_2 = 28 = 4.07$
$F.01\ n_1 = 4,\ n_2 = 28 = 2.71$

was highly significant. Therefore, the column to column variation is, beyond doubt, due to factors more than chance.

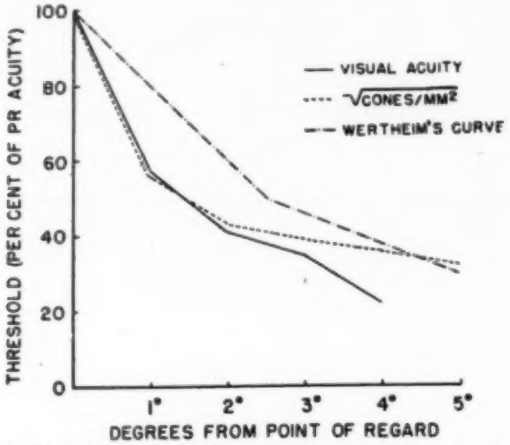

Fig. 10. Peripheral Visual Acuity Compared to Wertheim Curve (36) and to Retinal Cone Distribution (27) (N = 7)

The row to row variation (that is, meridian to meridian), $F_r = \frac{\hat{\sigma}\ r^2}{\hat{\sigma}\ e^2} = 2.59$, compared to Snedecor's F ratio,

$F.05\ n_1 = 7,\ n_2 = 28 = 3.36$
$F.01\ n_1 = 7,\ n_2 = 28 = 2.36$

means that since chance alone would cause as much or more variation than was observed, about 4 per cent of the time, we have at least fair evidence of the presence of some non-chance factor influencing the results.

Subject: ED

F_c observed = 189.32, compared with Snedecor's F ratio,

$F.05\ n_1 = 4,\ n_2 = 28 = 2.72$
$F.01\ n_1 = 4,\ n_2 = 28 = 4.09$

Thus, the column to column variation as observed was significant beyond doubt.

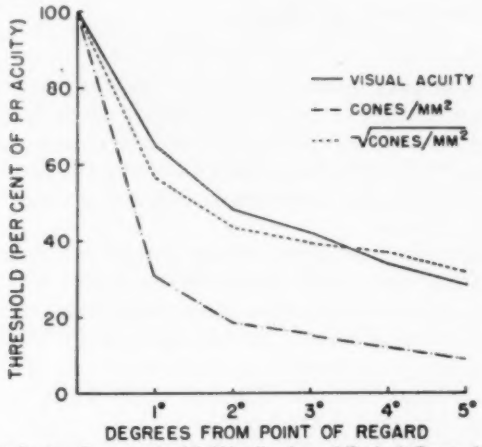

Fig. 11. Visual Acuity Compared with Distribution of Retinal Cones (27) (N = 5)

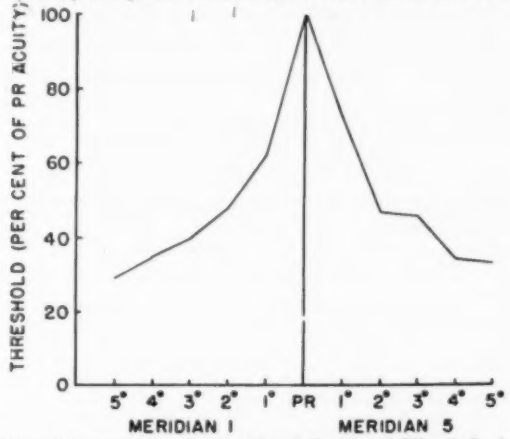

Fig. 12. Meridional Comparison (1 vs. 5) of Peripheral Visual Acuity (N = 5)

For the row to row (meridian to meridian) variation, Fr observed = 2.71

$$F.05\ n_1 = 4,\ n_2 = 28 = 2.37$$
$$F.01\ n_1 = 4,\ n_2 = 28 = 3.37$$

Thus, there is fair evidence of some non-chance factor.

To conclude then, in the studies of these two subjects, the column

to column (degree to degree) variation was significant beyond human doubt, whereas in row to row variation, there was at least some evidence of a non-chance factor operating.

CONCLUSIONS

1. The data as obtained in this study indicate that peripheral visual acuity tends to decrease as the distance increases from the point of regard more rapidly than has been heretofore indicated in previous studies.

2. Peripheral visual acuity follows closely the curve of the square root of the retinal cones /mm² upon which is dependent the discrimination of linear extents.

3. The variance of meridional peripheral visual acuity decreases in relation to the distance away from the point of regard. In other words, there is an increasing homogeneity of the visual acuity thresholds regardless of the meridional position as the targets are moved away from the point of regard.

4. Meridional positions compared with each other exhibit slight but apparently insignificant differences.

5. In the eight subjects studied, there is little evidence of correlation between point of regard visual acuity and peripheral visual acuity.

6. The curve of best fit for the peripheral visual acuity data obtained and for the $\sqrt{\text{cones}/\text{mm}^2}$ is a displaced hyperbola whose function may be stated as

$$y = \frac{61.413}{x + .790} = 22.044$$

7. Individual differences in maintaining levels of peripheral visual acuity are pronounced.

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THE PRACTICE OF VENTILATED CONTACT LENSES*

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This article is intended as a supplement to my introductory article on ventilated, solutionless contact lenses published in December, 1947.[1] Since the introduction of ventilated contact lenses, certain practical advances have been made to the methods of fitting employed, although no fundamental deviations have been introduced since the inception of the "ventilated" principle. It is the intention of this article, unlike my earlier notes, to deal with the practical aspects of fitting, adaptation and methods to be carried out.

Briefly the requirements deemed essential in the solutionless, ventilated type of lens are:

(a) to allow for a constant flow of lacrimal fluid to take place in the retro-lens chamber.
(b) for access of atmospheric oxygen to the cornea and particularly the limbal region.
(c) for the escape of the dissolved carbon dioxide.
(d) for the contact lens to fit sufficiently close to the cornea without exerting any pressure and at the same time to allow for adequate lacrimal filling of the lens without air bubbles transversing the pupillary region which could interfere with the vision.
(e) for freedom present in the perilimbal region with a well balanced scleral fit.

All these factors have to be considered fully and individually. In addition, a pleasant cosmetic appearance has to be maintained.

For ventilated contact lens fitting it would be wise to divorce the scleral fit from the corneal fit and treat each separately. The corneal fit must, by virtue of construction, contain most of the properties to satisfy the aforementioned conditions. Regarding the scleral fit, in my experience a finally satisfactory result is achieved if the lens contains a "curved" construction, as we find in lenses made to individual casts of eyes or various constructions of "curved" pre-formed lenses.

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[1]Bier, Norman. The Tolerance Factor and Sattler's Veil as Influenced by a New Development of Contact Lens Making. Am. J. Optom. & Arch. Am. Acad. Optom. 24.12.611-615.1947.

Pre-formed trial fitting: In order to attain the correct corneal fit, the writer thinks it essential to employ a specially designed ventilated corneal fitting case. It is important to make use of ventilated lenses for the fitting as the impression one may otherwise obtain, using a standard fluid type of lens, may prove entirely false. Any contact lens after ventilation immediately settles further on to the eye as compared to pre-ventilation. A steep or flat scleral fit in a pre-ventilated lens may be equally misleading in judging the corneal measurements. In order to attain a correct corneal perspective, a special corneal case is indicated. By separating the scleral and corneal fit the utmost economical advantage is obtained.

A corneal ventilated trial lens comprises a corneal portion surrounded by a narrow scleral rim of approximately 2 mm. width, so constructed as to give the flattest scleral fit likely to be called for. This is important as a steep scleral fit would otherwise unduly "raise" the corneal portion, giving a pseudo-clearance. A single vent pierces the sclero/corneal juncture. The following basic measurements are found to cater for nearly all the ocular corneal variations (contained in 26 trial lenses).

TABLE I

Corneal Radius	Corneal Diameter						
7.75	— 12.50,	13.00					
8.00	— 12.00,	12.25,	12.50,	12.75,	13.00,	13.25	
8.25	— 12.00,	12.25,	12.50,	12.75,	13.00,	13.25	
8.50	— 11.75,	12.00,	12.25,	12.50,	12.75,	13.00,	13.25
8.75	— 12.50,	12.75,	13.00,	13.25			
9.00	— 13.00						

(measurements taken in mm.)

The accuracy of measurement of the inside corneal surface has to be kept within very fine limits. The corneal ventilated contact trial lenses are used only to obtain the correct corneal measurement, the anterior surface of the lens not being optically worked, ordinary trial lenses still being employed for the estimation of the refraction. Although the use of an ophthalmometer may prove helpful in ascertaining the highest anterior corneal radius, from which the posterior corneal radius of the contact lens may be calculated, it is of less practical value than the corneal trial lenses. With the latter, not only can one stipulate the correct radius but also the diameter, in consequence the corneal height, thus the correctness of the corneal curve may be predetermined, its clearance and position may be immediately observed giving the data which will be required for the final lens.

TABLE 2

Corneal Radius	Corneal Diameter						
	11.75	11.87	12.00	12.12	12.25	12.37	12.50
7.50	2.84	2.92	3.00	3.08	3.17	3.26	3.36
7.75	2.69	2.77	2.85	2.92	3.00	3.08	3.16
8.00	2.57	2.64	2.71	2.78	2.85	2.93	3.01
8.25	2.46	2.52	2.59	2.65	2.72	2.79	2.86
8.50	2.36	2.42	2.48	2.54	2.60	2.67	2.74
8.75	2.26	2.32	2.38	2.44	2.50	2.56	2.63
9.00	2.18	2.24	2.30	2.35	2.40	2.46	2.52

Corneal heights shown in mm.

Although it proves sufficient for the corneal diameters to be graduated in 0.25 mm. steps in the fitting case, they may well be (and often are) ordered in $\frac{1}{8}$ mm. steps. A $\frac{1}{4}$ mm. variation in corneal radius proves quite adequate and smaller fractions are of little practical value.

One generally finds that two corneal trial lenses satisfy the same conditions as to filling, corneal pressure or clearance but differ in the alignment of the anterior curve of the cornea with the posterior contact lense curve. Thus one may find, for example, that an 8/13 (corneal radius—8 mm., corneal diameter—13 mm.) truly follows but just clears the corneal curve "all the way" and fills satisfactorily with lacrimal fluid. It is difficult to describe an absolute minimum corneal clearance but generally one sees the green fluorescein picture which is on the verge of turning purple or blue when finger pressure is applied on the exterior apex of the contact lens. A peri-limbal touch will be seen on the slightest provocation in a fit of this nature. Orthodox lag and sag are in consequence nonexistent. Although a contact lens fitting in this manner may be tolerated satisfactorily, one should fit a lens with a slightly flatter corneal radius giving a wider diameter and greater limbal freedom. Thus one would probably find that a 8.25/13.25 would give the desired fit, with good lacrimal fluid filling, two-thirds of the central corneal area being thus "covered" with the optical cap being truly followed and the corneal height of 3.33 mm. (see Table 2) being maintained. In effect an increase in corneal radius calls for a slightly larger increase in corneal height. The patient would ultimately achieve greater comfort and tolerance with the flatter lens.

In order to clear and lay free the limbal region in the final lens, a suitably constructed pre-formed contact lens should be employed in which the obviation of the sclero/corneal juncture is particularly stressed and incorporated. The internal transition should preferably be absent altogether, especially with molded lenses.

TABLE 2 (continued)

Corneal Radius	Corneal Diameter							
	12.62	12.75	12.37	13.00	13.12	13.25	13.37	13.50
7.50	3.46	3.56	3.66	3.76	3.87	3.99	4.11	4.23
7.75	3.25	3.34	3.43	3.53	3.63	3.73	3.83	3.94
8.00	3.09	3.17	3.25	3.34	3.43	3.52	3.61	3.71
8.25	2.93	3.01	3.09	3.17	3.25	3.33	3.42	3.51
8.50	2.80	2.87	2.94	3.02	3.09	3.17	3.25	3.33
8.75	2.69	2.75	2.82	2.89	2.96	3.03	3.10	3.18
9.00	2.58	2.64	2.70	2.76	2.83	2.90	2.97	3.05

Corneal heights shown in mm.

Some concession may be made for a minimum settling down of the contact lens after it has been in position for some time. This settling-down effect is much less in comparison to the settling normally experienced with fluid-type lenses: one should therefore err slightly on the steeper side of the corneal fit, and if the clearance proves too great in the final lens, the inside of the haptic may be ground out to settle the lens slightly as required. In general, lacrimal filling of the correctly fitting ventilated contact lens is completed in one to three minutes.

The laboratory must be able to calculate the optical prescription required for the particular corneal curve irrespective of the trial contact lens used. The estimation of the scleral measurements and specifications, as well as the optical formula, are taken independently to the corneal ventilated measurements. Due allowances should be made in the scleral radius when reducing or increasing the corneal diameter from any adopted standard corneal diameter. For example, an increase of ½ mm. in corneal diameter calls for a corresponding decrease of ¼ mm. in the scleral radius while maintaining the overall measurements and vice versa. Once the fitting is completed, the two measurements thus attained are combined for the specification of the final lens.

Molded contact lenses: Here again the scleral fit is kept apart from the corneal ventilated fit.

Ventilated corneal trial lenses are also utilized to ascertain the correct corneal measurements. While the required corneal radius may be specified it is impossible with molded lenses to grind the corneal diameter to the same accuracy as in pre-formed lenses. The laboratory, therefore, grinds a wider corneal diameter in the semi-finished lens to allow for settling of the lens which may take place when carrying out local modifications. The lens is then ventilated and should the clearance still prove too great, the lens is settled down by grinding out the area of the internal haptic to the desired corneal height. This procedure has proved

to be more satisfactory in practice than the regrinding of the internal corneal portion both for clearance and radius.

Ventilations: The writer generally starts off with a single vent placed temporally on the inside of the limbal juncture on a line between the internal and external canthus. After extensive experimentation, a circular vent of 1.2 mm. in diameter is now most generally employed and considered satisfactory for the final lens. A 1.5 mm. diameter is made use of in the corneal trial lens to attain filling at greater speed as well as permitting easy entry for the fluorescein solution. In order to obtain the best cosmetic appearance, care should be taken to place the vent in such a position at or near the limbus so that it is superimposed against the background of the iris. Provided the vent is correctly angled and finished, the appearance is rarely different to pre-ventilation. In a large number of cases, a single vent thus positioned within the palpebral apertures will suffice. Atmospheric conditions are then allowed to play their part in full in the closest proximity to natural conditions with the eye able to "breathe" more freely. Access is given for entry of atmospheric oxygen into the retro-lens chamber and dissolution of carbon dioxide from it. In some cases where the circulation and flow of lacrimal fluid is not radiated sufficiently, a further one or two (rarely more) vents may be incorporated superiorly and/or inferiorly underneath the eyelids. Generally it has been found that actual ventilations are more effective than ducts, channels or porous perforations, with the majority of patients. When further vents are indicated, they should be placed underneath the lids to uphold the cosmetic appearance. It is obvious that a single vent placed within the palpebral apertures is more effective than several similar openings placed underneath the eyelids.

Conclusions: In my opinion the veiling problem may be entirely overcome when all governing conditions have been satisfied. Sattler's Veil I defined in my original paper on this problem as onset of mistiness combined with colored halos observed around naked lights. With ventilated lenses the colored halos are absent altogether and the mistiness, if observed, is present in only a vague form incomparable to the density normally observed with fluid lenses. If present, it can be attributed to a corneal touch which may not be marked enough to cause corneal pressure when actual lacrimation would set in. In this connection, I would add it has been my experience after due experimental results, that it may be advisable for a scleral rim in contact lenses to be maintained to hold off and balance the optic from the cornea preventing any pressure. Over the past few years, hundreds of patients have been fitted with ventilated contact lenses by a number of practitioners and it may be said that their

introduction has been fully justified in the results achieved, despite the fact that much greater accuracy and painstaking care have to be accorded in the fitting of ventilated lenses. Although each case may present an individual problem, the general standard of results has improved, since changing to prescribing ventilated contact lenses. All day tolerances are not at all uncommon, although an occasional break during the day may be advisable. All those cases who formerly wore fluid contact lenses and have since been refitted with ventilated contact lenses have invariably achieved improved results. It would appear that however well a patient will do with fluid lenses, he will do at least twice as well with ventilated contact lenses.

Some observations recorded clinically are most helpful in formulating the final and correct fit with which invariably the maximum tolerances are achieved. Once the correct corneal curve has been found, it is the clearance which controls ultimate and complete success. We thus deal with six distinct stages.

Stage 1. Complete central clearance—bubble formation centrally—full fluorescein picture.

Stage 2. Capillary-like central clearance—absence of central bubble formation and fluorescein displaced upon central apical finger pressure.

Stage 3. Capillary-like central touch—absence of central bubble formation and fluorescein "just" displaced (delayed and inconsistent, often vague, blue fluorscein picture). Condition may or may not be accompanied by corrugation of stratified epithelium of cornea in peripheral one-third area of cornea, with or without slight mistiness observed after 4 to 8 hours. Mistiness does not increase in density with time.

Stage 4. Same condition where density of mistiness increases slightly with time, yet incomparable to "fog-like" veil experienced with fluid lenses.

Stage 5. Definite corneal touch (immediate blue fluorescein picture) usually accompanied by above described epithelial corrugation, with or without onset of mistiness 1 to 4 hours after normal veiling time with fluid lenses.

Stage 6. Definite corneal touch and pressure causing lacrimation after one-half hour to 3 hours.

Stage 2 offers the ideal fit. An estimated control of 3/100 mm. in central clearance calls for the highest accuracy in fitting.

Ventilated contact lenses in keratoconus: Where the condition has not progressed appreciably, the cornea may be treated as in normal cases

and a single corneal curve prescribed. The ventilated corneal fitting case is employed to attain the appropriate measurements. Although lacrimal filling may take a few seconds longer than in normal cases, it should nevertheless be complete. Care should be taken not to prescribe too flat a radius as too much deviation from the actual corneal curve may allow a circulating bubble which can be disconcerting to the patient. If the lens fails to fill up or if the keratoconus is marked and pronounced, a double corneal curve is indicated.

The scleral fit in ventilated contact lenses: It should be as prescribed in the orthodox type of pre-formed or molded lens with the fluorescein pool not extending beyond 2—2½ mm. from the limbus. All tight areas should be relieved and provided the edges of the contact lens do not stand off causing lid irritation, a small loose area need not be corrected as it allows additional lacrimal circulations. The fitting in this respect is thus simplified. The scleral fit as such, provided correctly balanced, is relatively less important in respect to the accuracy of the corneal fit and mainly serves, as do pillars, in correctly positioning the corneal portion. One school of thought formulates the theory that a loose scleral fit, particularly on extreme rotations, would be advantageous in that the movement of the lens may cause a rubbing action simulating the rubbing action of the eyelids over the cornea. No proof of this is available, however, although it may be partially responsible for the improved tolerances.

Since the advances some 10 to 15 years ago which made possible the modern fluid contact lens, no appreciable headway had been made in furthering the tolerance in view of the limiting factor of Sattler's Veil. Some solution had to be sought. It has been found by the introduction of the ventilated lens that in addition to its greater convenience in insertion and use, the limitation of Sattler's Veil has been largely overcome. That ventilated contact lenses are a distinct step toward solving the problem in its entirety there is no doubt viewing the results achieved. A certain risk had to be taken originally by coming into such close contact with the cornea and let it be admitted, some anxiety in this respect was felt initially. Nevertheless the results achieved fully justified the course adopted. Periodic examinations over a number of years have shown no ill effects whatsoever. Corneal pressure over a period of time which could conceivably cause corneal damage can rarely be tolerated by the wearer, excepting pathological cases. One cannot stress too often the exacting care and accuracy which has to be maintained in achieving the correct fit. Once correctly fitted, however, there is no doubt as to the results and the satisfaction achieved both by patient and practitioner.

To those practitioners in this country as well as in Europe and in the United States of America who have given me their constant encouragement and to the laboratory technicians without whose assistance and help the special procedure and techniques could not have been evolved and perfected, I would like to express my grateful thanks.

23 MANCHESTER STREET,
LONDON, W. 1, ENGLAND.

ABSTRACTS

VISUAL ACUITY AS MEASURED WITH VARIOUS ORIENTATIONS OF A PARALLEL-LINE TEST OBJECT. G. C. Higgins and K. Stultz. Journal of the Optical Society of America. 38.9.756. 1948.

Using the Snellen principle for a target made of alternating clear and opaque lines of equal width, the authors measured the visual acuity of normal, non-astigmatic observers for various orientations of the straight lines. The visual acuity was measured in terms of the reciprocal of the angle (in minutes of arc) subtended at the eye by an individual line at the limit of perception. When the orientation of the parallel-line test object was at 45° to the horizontal, the visual acuity was found to be significantly lower than at 0° or 90°. This reduction in visual acuity was measured to be anywhere from 10 per cent to 29 per cent. There was no significant acuity difference between the 0° and 90° orientations.

No physiological or optical reasons are brought forth in explanation of this phenomenon. However, the authors mention the fact that workers in the graphic arts are well aware of the decreased visibility of diagonal lines, and use the effect to their advantage by customarily making their half-tone prints with two orthogonal sets of parallel lines running diagonally through the visual field.

R. E. B.

THE EFFECT OF SPECTRAL QUALITY OF LIGHT ON VISUAL PERFORMANCE AND FATIGUE. Ernest Simonson and Joseph Brosek. Journal of the Optical Society of America. 38.10.830. 1948.

A great deal of inconclusive and inconsistent experimental work has been done on the effects of various pure spectral colors on visual functions such as visual acuity. However, no definitive information is available on the effects of spectral quality of illumination on work performance. The present study is a beginning in the right direction.

The authors designed batteries of tests involving recognition of very fine detail under three different illuminants at illumination intensities of 5, 100, and 300 foot-candles. The illuminants used were: 1. ordinary inside frosted lamps; 2. "natural white" lamps (with a white, slightly bluish coating); and 3. Verd-A-Ray lamps (with a greenish coating). All were compared at the same illumination level at the screen. It is stressed that each of these lamps emits essentially mixed white light, and that their color differences become apparent only when viewed simultaneously.

Six subjects were used, and their visual task, designed to be in the nature of conveyor inspection, consisted in the recognition of small letters. Performance levels were measured after five minutes, one hour, and two hours of work. The "performance drop" in such functions as flicker fusion frequency, abduction and adduction power, accommodation near point, convergence near point, and several ophthalmographic measurements served as one of the indices of fatigue. Subjective complaints and preferences were also taken into account.

Statistical analysis showed significant differences in the visual performances for the three illuminants tested. In general, these differences favored the greenish Verd-A-Ray lamp. The authors state that, at present, no statement can be made as to whether the spectral distribution of the Verd-A-Ray lamp is actually the optimum available, and ask for further systematic studies of the problem.

R. E. B.

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AN ALTERNATIVE TO COMPULSORY HEALTH INSURANCE

Since last Fall[1, 2] this Journal has viewed with concern the health plan of Oscar Ewing, Federal Social Security Administrator. During this period, we have urged our readers to use their influence against his proposals, for we believe that his ideas do not represent the traditional individualistic spirit of America.

Optometrists have responded in considerable numbers, opposing anything resembling socialized medicine. In fact, the count is more than eight to one against the Ewing plan. Further, they agree that sooner or later, the true spirit of free enterprise as evidenced by the freedom loving majority of Americans will have to call a halt to the socialistic reform minority that is attempting to undermine our

[1]Carel C. Koch. On the Retention of Free Enterprise. Am. J. Optom. & Arch. Am. Acad. Optom. 25.10.505-507.1948.
[2]Carel C. Koch. Optometry and the American Way of Life. Am. J. Optom. & Arch. Am. Acad. Optom. 25.12.593-595.1948.

democracy under the guise of welfare regimentation for the masses.

Some letters to the Editor suggested that while they opposed Ewing's federal health scheme, they would like to have the Journal suggest an alternative plan. This suggestion was also made by one of the several Congressmen to whom our objections were sent.

This is not difficult to do, but we do so reluctantly and only after again calling attention to the general success of present day health care and to the fact that the number of health agencies now operating are adequate to do the whole job if given some additional support.

A truly democratic health plan will not undermine the traditional character of our people and will not interfere with the free choice of practitioner or his relations with his patients. The following plan proposed by the writer meets these requirements, and is of a local character rather than one of national scope.

The program should be created at the state level and the detailed administration placed at the county and/or city level. This is not true of the Ewing plan. If it is necessary to enter this field, the writer believes a health program should be largely supported by local and state revenues and if federal grants are to come, these should be entirely without strings and the monies should be raised from direct taxation. One of the many objectionable features of the Ewing proposal is additional indirect taxation through Social Security.

The suggested plan on a state basis can be similar to the housing programs of the pre-world war II period, which were created by state enabling acts and which received some federal aid as the plans developed. In housing, the administration was left at the local urban level. The state is a large enough unit to assure proper planning and study, yet small enough to be close to the particular needs and problems of its citizens.

Further, the plan must be directed to assume all of the health requirements of the indigent.* It must also assume a few of the health burdens of the gainfully employed when they find it impossible to assume them. In this latter category the wage earner is medically indigent only when his medical expenses materially exceed his current income and liquid savings.

In a study of health care one must clearly define the term, "medically indigent."

A medically indigent person is one whose income is adequate to

*As before the Senate in the fourth week of the 81st session the Bill, formerly S 1320 and now S5 will assist only the employed and the self employed. Indigent persons making no contributions will not be assisted under this program and will remain wards of the local communities.

meet all ordinary health costs but whose income and liquid savings are inadequate to meet an unexpected major illness.

For example, take a family consisting of an employed man, his wife and one child. Say the family's total income is $3,000.00 a year. The family is purchasing its home on a contract for deed which calls for monthly payments of $48.00 which includes interest and insurance. The family has $225.00 in liquid savings. Is this family medically indigent according to our definition?

For minor illnesses, dental and optical care the family is self supporting and well able to meet their doctor bills. In this respect they are not medically indigent. For serious illnesses such as major surgery, polio or long convalescent care—particularly for the family provider—the family *is* medically indigent, as the cost would require a serious change in living standards and perhaps even the loss of their home.

A state-wide program of health assistance for the indigent and emergency grant-in-aid financial assistance to the medically indigent could be provided by expanding existing facilities. This type of program would be responsive to the wishes of the voters in a state. The plan could be supervised by existing county welfare boards and the added cost to the public would be but a fraction of that proposed by Ewing.

In addition, the plan should include the provision that wherever possible, and without hardship, the recipients of grants-in-aid could repay the program when and as conditions permitted, to enable these temporarily medically indigent to retain their self respect as citizens, and not feel they were wards of the government.

Further, the program should be in effect only in those states where the voters had approved the program by a referendum.

Socialistic proposals have a tendency of reducing the scale of living standards wherever applied. In America, with its already high standards of health care, the result of the Ewing plan would be to reduce these standards available to a majority of the people in the effort to supply them for the minority. This is a bad bargain for the American people and one which should be defeated.

As pointed out last month in this Journal,[3] a scheme similar to the Ewing plan was supported by British optometrists during 1947 and 1948. Today, with the program working out of its supplementary stages into its more permanent form, Ross-Mansell, Editor of the *Journal of the Institute of Optical Science*, (London), says,[4] "The opti-

[3]Virginia Huck. Observer Finds British Health Program Demoralizing. Am. J. Optom. & Arch. Am. Acad. Optom. 26.2.91-94.1949.
[4]J. Ross-Mansell. Editorial. Journal of the Institute of Optical Science. (London). 5.16.500. Jan. 1949.

cal profession is in real danger of extinction once the permanent scheme comes into effect." Thus we see that six months after becoming part of socialized medicine the optometrists of England are awakening to the dangers of this program, and now seem helpless to extricate themselves.

American optometrists still have time to fight *all* of these proposals. We must remember that minority political groups are well organized. They realize, despite their numerical inferiority, that if they campaign loudly enough for a program of social betterment, no matter how fantastic or wasteful this may be financially, that they can count on the support of a fair segment of "do-gooders" who wish to be regarded by their fellow citizens as sympathetic to the underdog.

These minority groups also realize that by asking for far more than they hope to achieve, in a democracy they have a fair chance of getting the government to compromise on something which they call a social gain, as politicians usually are fearful of taking a non-reform stand.

If compromise we must, let it then be for a program of health assistance at the state and local level only.

CAREL C. KOCH

ABSTRACTS

A COMPARATIVE STUDY OF FIVE TESTS OF COLOR VISION. A. Chapanis. Journal of the Optical Society of America. 38.7.626. 1948.

Five prominent pseudo-isochromatic tests of color vision were evaluated, each as a whole, and plate-by-plate, to determine their relative efficiency in distinguishing color-normal from color-deficient persons among a group of 120 men. The Royal Canadian Navy color vision test lantern results, which correlated highly with the pseudo-isochromatic test findings, enabled classification of the subjects into 86 color-normal men and 34 color-deficient men.

The author concludes that the Bostrom-Kugelberg test is by far the most reliable in differentiating clearly between color-normal and color-deficient groups, since its individual plates are highly diagnostic, and an excellent numerical design is used. The next best test is the Ishihara series, which is highly satisfactory, except for its "hidden-digit" plates. The American Optical Company test is less useful, because many of its plates are not diagnostic, and the numeral design is poor, leading to confusion. The AO test, because of the large number of plates, does enable differentiation of color-normal from color-deficient individuals, but only half the plates are worth retaining. Finally, the Meyrowitz and the Bostrom tests are both generally unsatisfactory, affording no clear-cut differentiation; many of the plates are non-diagnostic, and the numerical designs poor.

The author also concludes that neither age nor visual acuity bears a sifinificant correlation to performance on any of these color vision tests.

R. E. B.

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department: such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

"NOTHING YOU BUY COSTS YOU SO LITTLE—YET GIVES YOU SO MUCH"

In February, this writer had the privilege of lecturing to University of Minnesota journalism students on the problems of editing a scientific journal. The questions asked during the question and answer period, were not, however, entirely about editing. One of the questions was, "Does the profession of optometry have a public relations program designed to inform the public about professional eye care?"

I was glad to be able to answer, "Yes, several programs, one of which is the Better Vision Institute," and explain their program of reaching the public in a manner acceptable to the profession. Many of the students had seen B.V.I. ads, but of course did not connect them with any single eye specialist.

This incident is gratifying in that it shows the public definitely is interested in knowing more about professional eye care, and that a program such as that of the Better Vision Institute is invaluable to the profession.

This year, B.V.I. is concentrating on counteracting the widespread public impression that glasses and eye care cost more than they should. The 1949 program will be built around the slogan, "Nothing You Buy Costs You So Little, Yet Gives You So Much." It will place constant emphasis upon the moderate costs of eye care and the scientific character of professional services and skills, through books for patients, editorial articles for leading magazines, radio programs, and educational brochures.

An extensive program such as this needs the full support of the profession. Returns on membership this year are gratifying, B. V. I. officials report, but more backing is needed to do the whole job. Why not join B. V. I. and do your part to aid the profession in getting the message of professional eye care across to the public? The Better Vision Institute, Inc., is located in Suite 3157, 630 Fifth Avenue, Rockefeller Center, New York 20, New York.

ANISEIKONIC WORK AT COLUMBIA

Aniseikonia patients may now be referred for treatment, investi-

gation and measurement to the Optometry Laboratory at Columbia University. According to Dr. C. L. Treleaven, Dean of the Laboratory, about five patients a week can be taken care of during the school year with the recently acquired space-eikonometer which was developed by American Optical Company in collaboration with the former Dartmouth Eye Institute.

The space-eikonometer measures aniseikonia by means of binocular space perception localization which is affected by the disparity present when the ocular images are unequal in size or shape. In addition to the space-eikonometer the Laboratory is equipped with an ophthalmo-eikonometer, a simplified eikonometer, and one of the early experimental models of the vectograph space-eikonometer.

Aniseikonia patients will be under the care of Drs. Robert E. Bannon, Harold M. Fisher, John Mogey, Rudolph Textor, and C. L. Treleaven, all of whom took special training in aniseikonia at Dartmouth Eye Institute.

For the present, Dr. Treleaven says, each patient accepted for aniseikonic study will be cared for in the laboratory by an individual instructor specially trained in this work. Patients will be accepted either for a complete case study and recommendations, or for measurements of aniseikonia only.

Where a complete case study is desired, request for an appointment should be made by the referring optometrist by mail. The optometrist should provide a case record as complete as possible with the application. Reasons for suspecting aniseikonia are to be indicated by the referring optometrist. On completion of the laboratory study a complete report will be made to the optometrist, including recommendations, prescription, and complete instructions for ordering iseikonic glasses from the American Optical Company.

Where the patient is referred for aniseikonic measurements only, the laboratory report will be confined to that factor. In such cases, no prescription will be written or any recommendations made, other than to report the aniseikonic measurements obtained.

No charge will be made for either kind of laboratory service.

Appointments may be made by addressing the Optometry Laboratory, Columbia University, 433 West 123rd Street, New York 27, New York.

Plans are in the offing for a postgraduate seminar in aniseikonia if a sufficient number of optometrists show an interest by writing to the laboratory, according to Dr. Treleaven.

EZELL CALLS FOR ADDITIONAL FOUNDATION MEMBERS

April has been designated "American Optometric Foundation Month," according to Dr. William C. Ezell, Foundation president. During April, the Foundation will make a concerted drive to raise funds for the Foundation, an organization started in 1948 to promote professionalism in optometry and provide funds for research in the field of optometry.

States have been organized by zones for the drive, and zone chairmen will endeavor to contact every optometrist before the end of April. Dr. Ezell is urging that optometrists make the job of State chairmen easier by mailing in a check for either active membership or life membership to Dr. Harold V. Hutcheson, Secretary, American Optometric Foundation, Inc., 37 Main Street, Tarrytown, New York, or their State chairman. Active membership is granted for $15.00, and life for $500.

Generous support has already been given to the Foundation by the schools of optometry, optometric fraternities, other undergraduate groups, and women's auxiliaries, as well as individual optometrists, and professional optometric societies, Dr. Ezell reports.

VIDEO TO AID SCIENTIFIC UNDERSTANDING

The industry of television is rapidly growing up, and with it, an opportunity for scientists to satisfy the public's thirst for scientific knowledge. Simple scientific experiments have already been televised and met with an enthusiastic video audience. Several of these experiments were written up in the January issue of *Physics Today*, in an article entitled, "Televising Science," by Roy K. Marshall. Marshall, who is director of the Franklin Institute's Fels planetarium, takes you behind the scenes and explains how a science program is televised. We recommend his detailed and comprehensive article to Journal readers. (*Physics Today*, a general interest journal on physics, is published at Prince and Lemon Streets, Lancaster, Pennsylvania, with editorial offices at the American Institute of Physics, 57 East 55th Street, New York 22, New York.)

Not only is Marshall's article informative, but it starts one thinking about the possibilities for optometry in the field of television. Television, in the writer's opinion, would be an excellent medium for putting optometry's message of professional eye care across to the public, provided, of course, the programs were on a scientific and professional level. Especially interesting to video audiences, we think, would be a program televising an actual fitting of contact lenses.

NEWS BRIEFS

The American Board of Opticianry has appointed three Minnesotans to service on its Advisory, Educational and Professional Council for 1949: Dr. Charles Sheard and Dr. William L. Benedict of Rochester, and Dr. Carel C. Koch of Minneapolis. . . . The Continental Optical Company of Indianapolis and the May Manufacturing Company of New York City have joined the membership of the Better Vision Institute, bringing the total of manufacturer members to fifteen. . . . The National Society for the Prevention of Blindness held its annual conference at the Hotel New Yorker, New York City, March 16-18; Commander Roswell Sullivan represented optometry, discussing the contribution of the optometrist to the Navy eye program. . . . Four hundred educators from both public and parochial schools attended the second annual reading conference of the Northeastern Ohio Chapter of the American Academy of Optometry in February. At many sessions it was "standing room only." . . . Nearly 500 students were awarded Doctor of Optometry degrees at the February graduation exercises of Northern Illinois College of Optometry. . . . Southern College of Optometry has added a new member to its teaching staff—Dr. William Arthur Womble of Memphis, Tennessee.

BOOK REVIEW

EDUCATION FOR WHAT IS REAL. Earl C. Kelley (Wayne Univ.). Foreword by John Dewey. Harper & Bros., N. Y. 114 pp., $2.00, 1947.

This small, well-written book advocates a "reform movement" in modern education. The approach is based upon certain experimental phenomena in the field of *visual perception* demonstrated by Albert Ames of the Hanover Institute. Because of the visual experiments described and their application in the field of education, this book may be of interest to those in the visual sciences. Ames' demonstrations point out that seeing is not a simple reproduction of the stimuli, but depends upon a set of clues peculiar to the observer, conditioned by previous experience, current interests, and actions.

It is claimed that the conclusions reached as a result of Ames' visual perception experiments revolutionize the whole concept of the relation between the individual and his environment. John Dewey points out in the Foreword that here for the first time is an experimental demonstration of the principles governing the development of perceiving. Professor Kelley believes that Ames' experiments help to supply

in a laboratory way what has been lacking in man's understanding of the relation between the human organisms and his environment, including education, human relations, diplomacy, art, etc. The author, speaking as a teacher, contends that if one can really master the basic facts of perception, they will aid him in guiding the growth of his children and assist him in his beliefs about teaching and learning. The basic hypothesis expounded in this book is that one cannot learn by authority, but by experience only.

In the first chapter, the author attempts to show the need for a new approach to man's problems by establishing the fact that all is not well with the world. Fear seems to be the outstanding characteristic of our age and is responsible for most of our problems. Fear is used for disciplinary purposes from the cradle up and it makes us suspicious of all the different classes of people with which we come in contact. Cooperation, rather than a basic habit of suspicion, is needed to solve our social, educational, and political problems.

Chapter Two reviews some common assumptions of education with the aim of determining if they tend to solve, or to create, the conditions described in the first chapter. It is concluded that if the child acquires habits of fear and coercion in school, his attitude toward people and toward the world will be one of suspicion. If the child has not had "living experience" in school, he will have to commence to live outside as best he can. The child, or future adult, will be cooperative and social to the extent his education has taught him to be.

The subsequent chapters deal with the Hanover Institute demonstrations in perceptions, their implications in how vision connects man with his environment, and the meaning of the demonstrations for purposes of teaching, learning and growth. Sensations do not come from one's present environment, but from past experiences. An object is what one calls it and it is labelled according to how it fits in with prior experience. Reality, then, is only what each individual makes it. The great problem of human relations is that different people do not have the same background and therefore do not have the same view of reality. It is claimed that realization of this is one step in understanding which should lead to tolerance.

The final chapters describe how education can be more real by making use of what is known about perception and reality; how the teacher can bring the child and the subject matter together in concrete experience; and, finally, there is a discussion of ways in which man can live with others in a social world and yet be distinct in experiential background and purpose.

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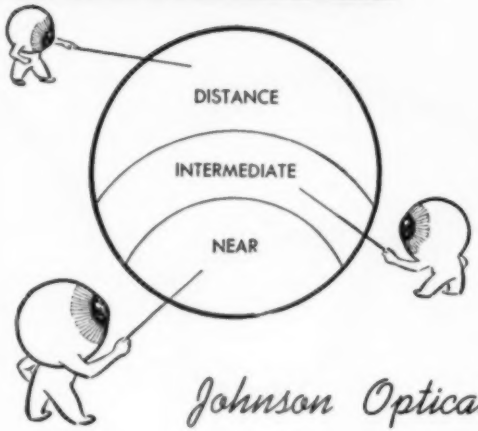

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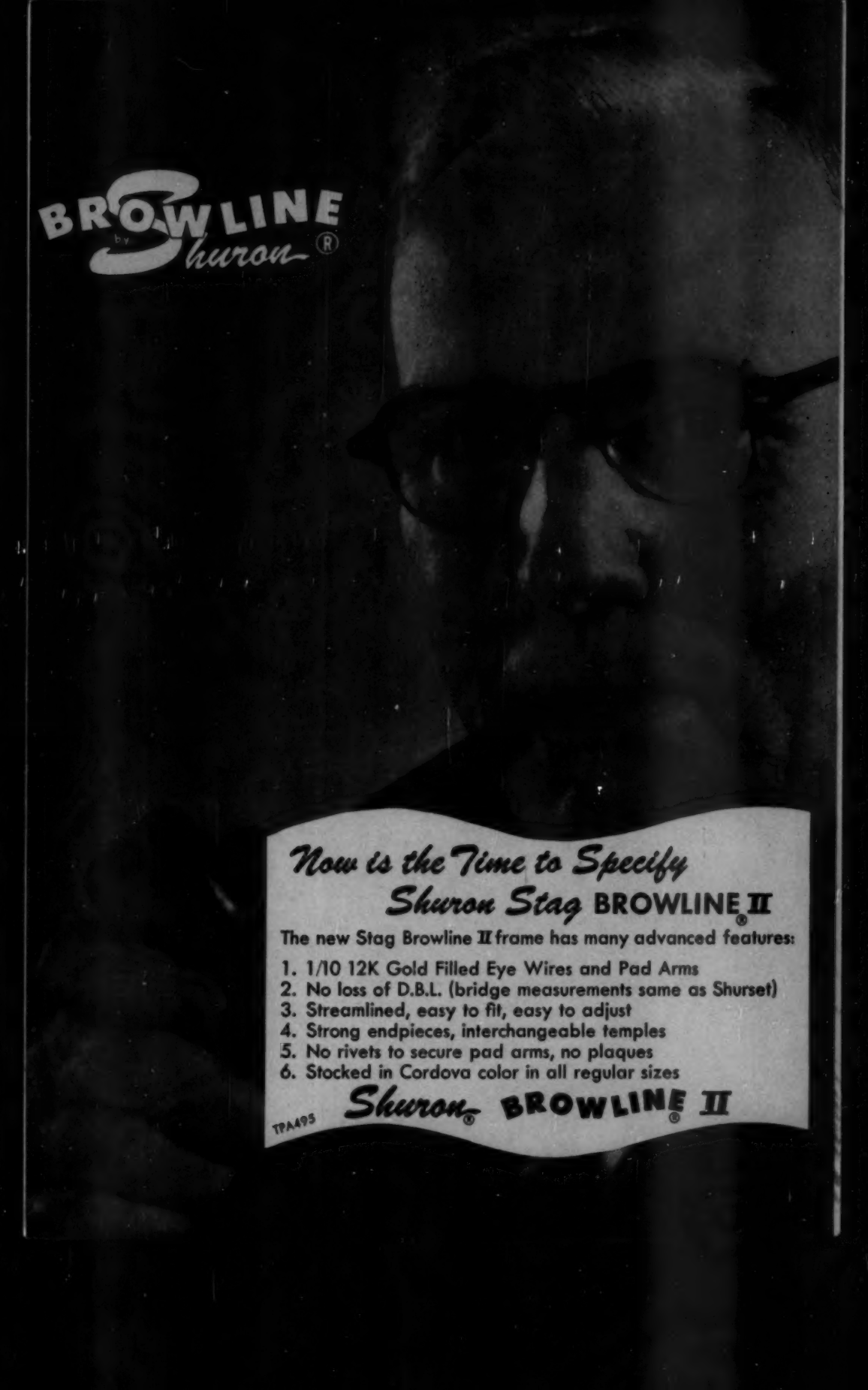
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